Progressive T&E And The Virtual Missile Range

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NDIA Systems Engineering Conference – Involving T&E in Systems Engineering

22-25 October 2001, Dallas, TX

Summary

A sea-based Virtual Missile Range (VMR) consists of an at-sea ship being externally stimulated by a synthetic threat and "firing" a simulated weapon at that synthetic threat. The Naval Air Systems Command's (NAVAIR's) sea-based VMR became a reality because of progressive land-based test and evaluation (T&E) opportunities. By electronically linking existing land-based facilities and performing a progressive three-phased land-based T&E strategy, a complete land-based VMR was established. The success of the land-based T&E strategy led to the success of the progressive two-phased sea-based T&E efforts with the Self Defense Test Ship (SDTS). The first event was held off the California coast, the second was held 60 miles away, off the San Nicolas Island (SNI) coast. The successful VMR sea-based events continued with the full-up operational demonstration with the FLEET ship USS KINKAID.

To the USS KINKAID's Combat Operations Crew(s), the incoming synthetic threats were realistic. The ships weapon stations were indicating an incoming threat. The ship's crew(s) locked onto that incoming threat and "fired," from their perspective, a live NATO SeaSparrow Missile (NSSM). The missile they really "fired" was the NSSM housed within the mainland's Hardware-In-the-Loop (HIL) laboratory. That initial simulation, utilizing the ship's pre-launch and post-launch data, as well as the synthetic threat data, led to a successful end-game termination of the inbound synthetic threat (a lethal miss distance was achieved) and the crew(s) saw that incoming threat disperse.

Introduction

During the early 1990's the concept of electronically linking surface weapons laboratories, located at the Naval Air Warfare Center, Weapons Division at Point Mugu, California (NAWCWD), with the surface ships laboratories, located at the Naval Surface Warfare Center-Port Hueneme Division at Port Hueneme, California (NSWC-PHD) was formulated. These warfare centers were located only six miles apart. Further design investigation revealed that the Naval Surface Warfare Center-Indian Head Division, Indian Head, Maryland (NSWC-IHD) produced a Missile All-up-Round Simulator (MARS) unit, which replaces, for one, a NSSM within the MK-29 launcher tube. The MARS unit simulates all aspects of a missile, in the launcher tube, including the “missile-away” mechanical indicator. Other facilities and assets, which became integral parts of the VMR included:

- The Surface Warfare Engineering Facility (SWEF). The SWEF is located directly on the California coast at NSWC-PHD and is comprised of the MK-23 Target Acquisition System (TAS), the MK-95 NSSM weapon system and fire control radar, the MK-29 NSSM Launcher, and the Combat Crew’s Operational Console.
- The NSSM HIL. The NSSM HIL is an integral part of the NSSM and Evolved SeaSparrow Missile (ESSM) Developmental Test/Operational Test (DT/OT) process. It is comprised of the actual missile(s), minus the propulsion and ordinance, and is mounted on a 3-axis motion table within the anechoic HIL. The HIL is 41’(W)x38’(L)x35’(H) and has 48 phased-array emitters, which can simulate up to 4 incoming threats simultaneously.
- The Self Defense Test Ship (SDTS). The SDTS is a fully operational ship with FLEET representative weapons and sensors. Amongst it assets are the MK-23 Target Acquisition System (TAS), the MK-95 NSSM weapon system and fire control radar, and the MK-29 NSSM Launcher. It is the ex-USS DECATUR (DDG-31)
- The Synthetic Target Generator (STG). The STG consists of two receive and two emitter antennae as well as two Digital Radio Frequency Memories (DRFMs) modulators contained within an AN/ULQ-26(V) Target Generator.
- The Synthetic Missile Interface Terminal Hardware (SMITH) unit. Passive taps, via low impedance extension cables, capture specific missile pre-launch and post-launch data. The SMITH unit stores the captured data and transfers this data to a wireless data link unit.
- The Wireless Data Link (WDL). The WDL is a high-speed commercial product consisting of a Multipoint Base Station (brought aboard ship), an omni-antenna (also brought aboard ship), and a Remote Workgroup Bridge (located on SNI with a directional antenna).
- The Real-Time Simulation Protocol (RTSP). The RTSP is a software package that enables high performance real time distributed simulation across a communication network. The main RTSP goal is to maximize real time performance. By performing computations during the VMR initialization phase the compilations required during real time operation are minimized. In the final VMR configuration, the RTSP will initiate and control the STG, the SMITH unit, and the HIL simulation for all VMR events.
- The fiber-optic cable link between SNI and the mainland NAWCWD.

Concurrent to the concept of a land-based VMR, the robustness and availability of portable wireless communications prospects were also accelerating. The initial concept of linking laboratories then grew into linking actual FLEET ships-at-sea with mainland laboratories. If this concept were attainable, then the simulation portions of the HIL’s shipboard pre-launch and post-launch signals could be replaced with the actual, at-sea, shipboard, pre-launch and post-launch signals. This would enhance the DT and OT opportunities of not only the missile, but also the shipboard weapon systems.

Supplementing the enhanced DT/OT opportunities by linking ships-at-sea with mainland laboratories, was the NAWCWD capability of providing synthetic threat stimulation to at-sea ships. If an at-sea ship could be stimulated with a realistic incoming synthetic threat, and if the ships crew could lock onto that incoming synthetic threat and "fire" a laboratory missile, a sea-based Virtual Missile Range would be – a reality!

Designing, developing, and "T&Eing" this at-sea concept was initially thought to be a high-risk venture. However, when the initial "land-based only" concept was resurrected as a "T&E opportunity," the risk factor was greatly reduced. If the entire sea-based end-state could be duplicated on land, then "T&Eing" the VMR became a low-risk venture. The T&E disciplines of being involved early, starting small, and progressively testing and evaluating the full-fledged end product, would be the modus operandi.

Land-Based T&E, Phase 1

The initial VMR design was a basic, land-based, Phase 1, T&E configuration. This consisted of: 1) a land-based, high-speed, hard-wire linkage between the NSWC-PHD SWEF and the NAWCWD NSSM HIL; 2) a rudimentary, portable STG located at Point Mugu, directed toward the SWEF at Port Hueneme; and 3) integrating the RTSP software control between the "laboratory-ship" and the "laboratory-missile." The T&E objective was to see if the Port Hueneme SWEF could recognize a Radio Frequency (RF) signal emanating from Point Mugu and "ping" the Point Mugu NSSM HIL.

VMR Communications Engineers connected the SWEF and the NSSM HIL via a T1 line as shown in Figure 1.

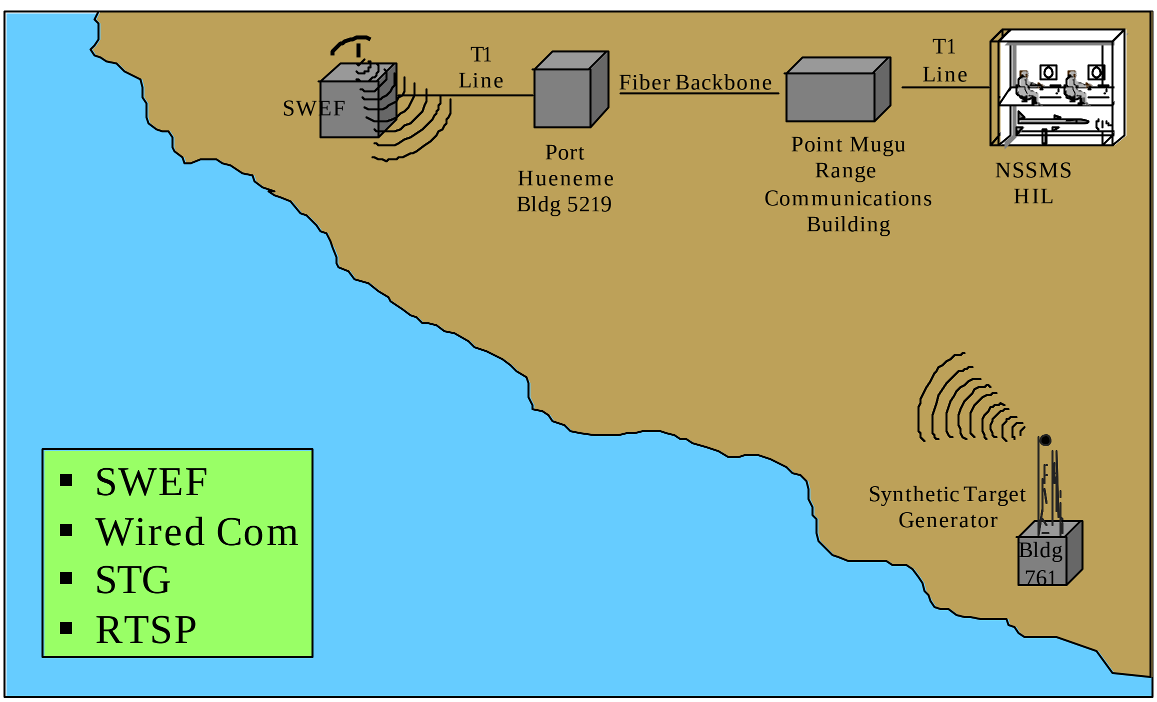

Figure 1. Land-based T&E, Phase 1

After minor adjustments in each Phase 1 node, it was determined that the SWEF could recognize an RF signal emanating from Point Mugu and “ping” the NSSM HIL. Phase 1 of the T&E process was deemed a success.

Land-Based T&E, Phase 2

The land-based Phase 2 T&E effort consisted enhancing the Phase 1 structure by: 1) inserting the MARS unit into the SWEF’s MK-29 NSSM Launcher, 2) passively tapping the weapon system’s pre-launch and post-launch signals, 3) gathering those pre/post-launch signals and sending them to the NSSM HIL for missile flight execution, and 4) “launching” a simulated missile from both the MK-29 and the NSSM HIL. The T&E criteria for this phase of testing was: 1) having the SWEF “see” the presented RF signals emanating from Point Mugu as threats; 2) successfully transmitting accurate pre/post-launch data to the NSSM HIL, utilizing the RTSP; 3) “triggering” the MARS and HIL simulations simultaneously; and 4) exercising the HIL simulation to a successful missile end-game. The Land-based T&E, Phase 2 diagram is shown as Figure 2.

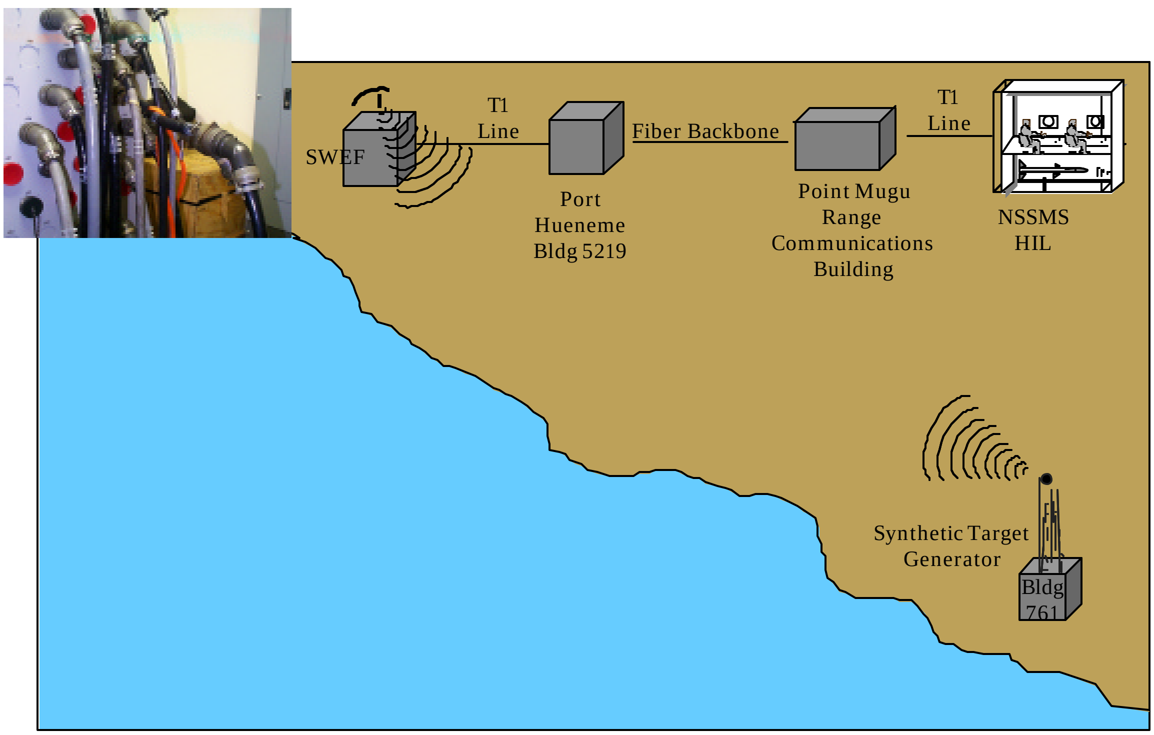

Figure 2. Land-based T&E, Phase 2

For Phase 2 T&E, only minor adjustments were necessary with the progressively increasing realm of the VMR. The SWEF saw the RF threats as realistic threats, pre/post-launch signals were successfully gathered and sent to the NSSM HIL utilizing the RTSP, the MK-29 Launcher was activated, and a successful missile end-game simulation was played out within the HIL.

Land-Based T&E, Phase 3

The land-based Phase 3 T&E effort consisted of enhancing the Phase 2 structure by: 1) disconnecting the hard-wired connection between the SWEF and the HIL and replacing it with a high-speed wireless network; 2) linking the STG, to the HIL, via a secure VMR Local Area Network (LAN) utilizing the VMR specific communication electronics contained in a Joint Interface Missile Simulator (JIMS) unit; and 3) integrating a Global Positioning System (GPS), for the STG, into the VMR simulation, as illustrated in Figure 3.

The Phase 3 T&E criteria for success was: 1) simultaneously initiating the STG, the SMITH unit, and the HIL via the RTSP; 2) successfully gathering and transmitting accurate pre/post-launch data to the NSSM HIL via the WDL; 3) simultaneously "firing" (missile away) both the MARS and HIL simulation from the SWEF's Combat Operations Center; and 5) exercising the HIL simulation to a successful missile end-game.

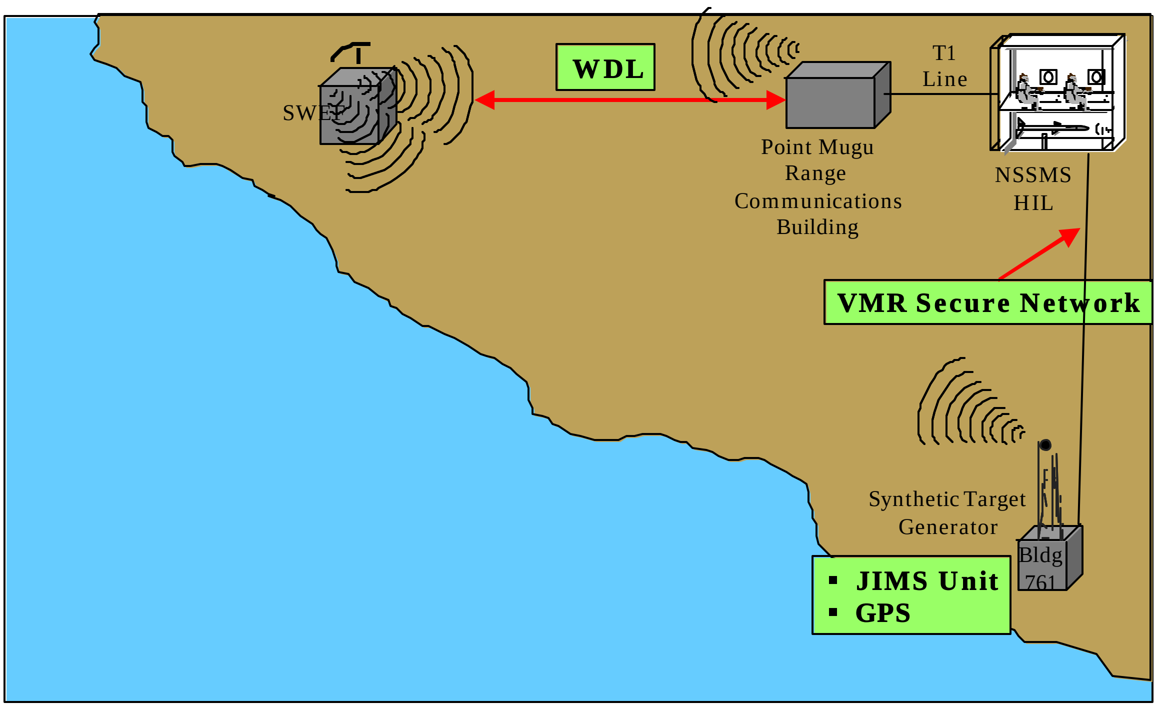

Figure 3. Land-based T&E, Phase 3

The Phase 3 T&E required only minor adjustments to successfully complete the "all-up-round" land-based VMR. The RTSP simultaneously initiated the STG, SMITH, and HIL operations; synthetic, incoming threats were presented to the SWEF; pre/post-launch signals were gathered and sent, via the WDL, to the NSSM HIL; the MK-29 Launcher was activated; and a successful missile end-game simulation was played out within the HIL.

Sea-Based T&E, Phase 1

The sea-based Phase 1 T&E effort consisted of substituting the mainland SWEF with the at-sea SDTS. This required transferring all of the portable VMR ship installation equipment, which had only been used within the SWEF, to the sea-going SDTS. The VMR ship installation equipment consisted of: 1) the SMITH unit and all of the related wiring and extensions required to passively tap into the SDTS weapon system; 2) the GPS unit; 3) the WDL and associate antennae; and 4) the MARS unit. The Sea-based T&E, Phase 1 is diagramed in Figure 4.

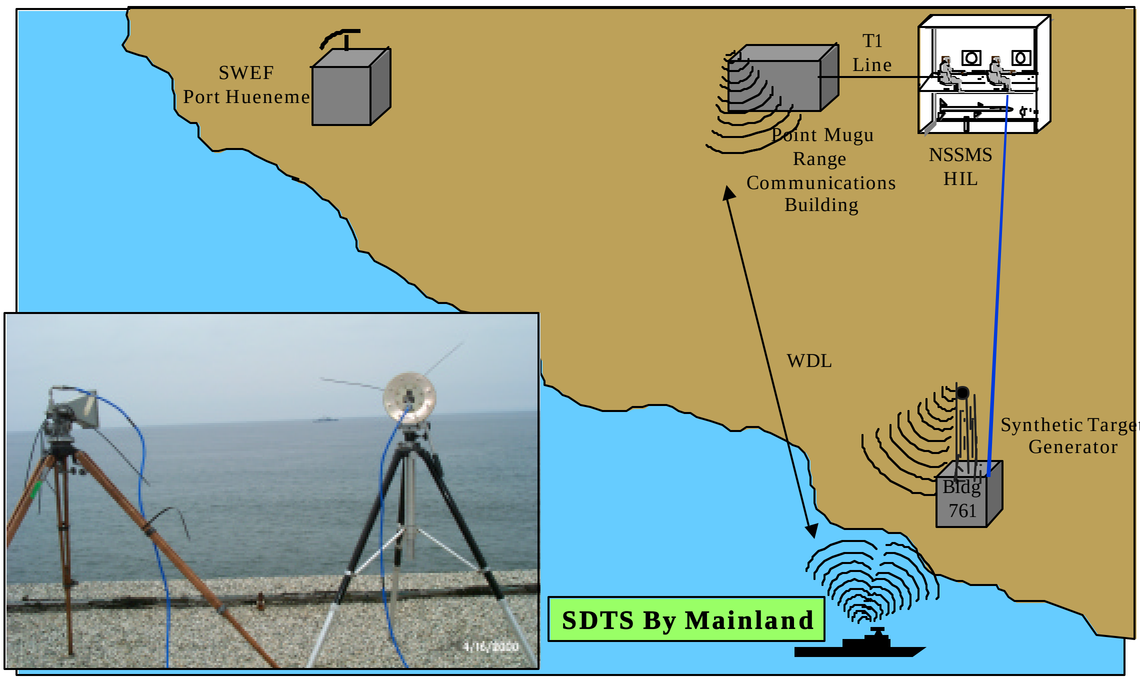

Figure 4. Sea-based T&E, Phase 1

For this test, the SDTS was positioned 2 miles off the California coast. The STG electronics and antennae were mounted atop a Point Mugu coastal building, and pointed toward the SDTS. The land-based WDL receiver/transmitter was placed atop another, inland, Point Mugu building. On 16 June 2000, the first attempt to operate the VMR in an operational condition took place.

This initial sea-based Phase 1 T&E was a success. The high-speed WDL accurately transmitted and received data between the two sites; the RTSP simultaneously initiated the STG, the shipboard SMITH, and HIL operations; the synthetic, incoming threats were presented to the at-sea SDTS; pre/post-launch signals were gathered from the ships weapon system and sent, via the WDL, to the NSSM HIL; the shipboard MK-29 Launcher was activated; and a successful end-game missile simulation was flown in the HIL.

Sea-Based T&E, Phase 2

The objective of the sea-based Phase 2 T&E effort was to conduct the VMR 60 miles from the California coast, its operational end-state. This required transporting the STG and the land-based WDL node to SNI. The STG was located on the SNI coast as shown in Figure 5. The STG was installed at ground level, approximately 30 to 50 feet above sea level. The WDL node was installed atop the SNI communications building and hard-wire linked into the existing fiber-optic cable, which runs along the ocean floor to NAWCWD.

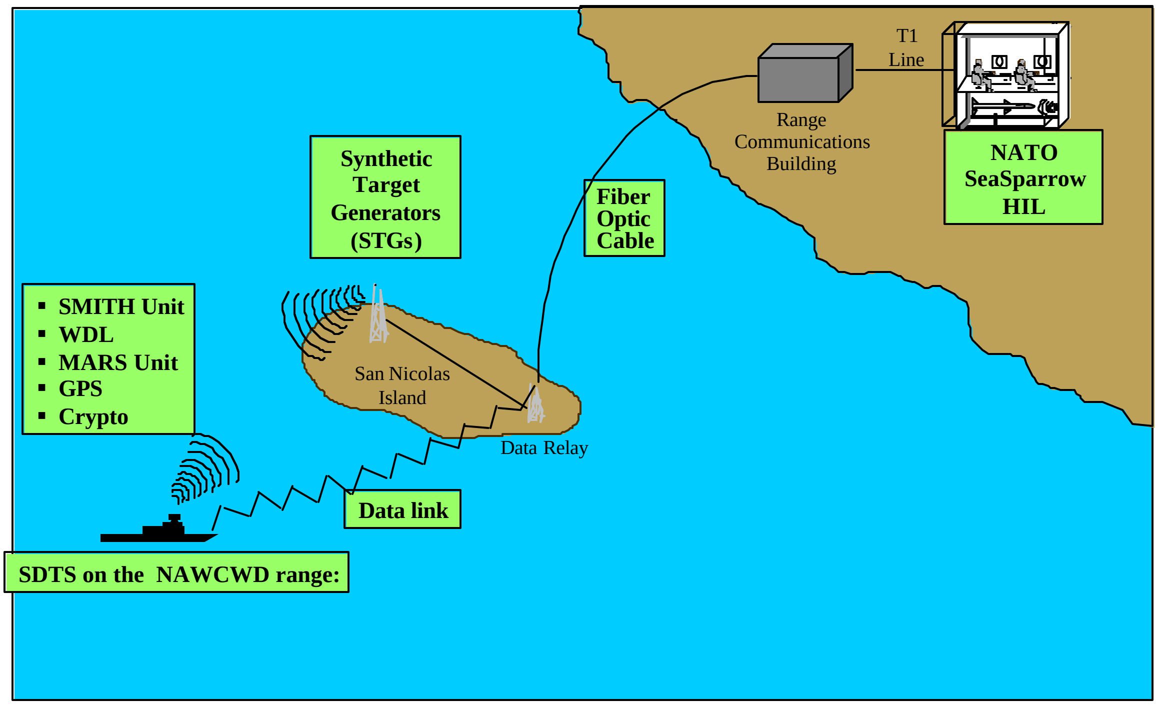

Figure 5. Sea-based T&E, Phase 2

For this test, the SDTS was positioned two miles from the STG. On 07 September 2000 the sea-based Phase 2 effort took place and was another success. This was the final, 5-phased, progressive T&E event scheduled. The high-speed WDL to SNI and the fiber-optic cable link to the HIL transmitted and received data accurately; the RTSP controller, located within the HIL, simultaneously initiated the SNI STG, the shipboard SMITH, and HIL operations; synthetic, incoming threats were successfully presented to the at-sea SDTS; pre-launch signals were gathered from the ships weapon system and transmitted and received accurately at the NSSM HIL; the shipboard MK-29 Launcher was activated; and a successful end-game simulation was played out within the mainland HIL.

USS KINKAID Demonstration

The operational demonstration was held on 12–13 September 2000. This initial version of the VMR was conducted on the NAWCWD Sea Range. The demonstration consisted of: 1) a series of synthetic target presentations against the USS KINKAID, DD-965, located off the coast of SNI, as well as, 2) end-game simulation engagements against those incoming synthetic targets. The USS KINKAID's NSSM was "flown" in the NSSM HIL laboratory located at NAWCWD.

Compared to other ship/threat engagements, this operational demonstration had several distinct differences: 1) it did not use a target drone, 2) it did not use a valuable Sea Sparrow missile, 3) no range-surveillance aircraft from Point Mugu were needed to ensure that the area was clear of unauthorized shipping, and 4) target recovery was not required.

Unlike a live fire exercise, this scenario could be run again within minutes, repeatedly, or with any variations. Each test repetition would generate new information on systems' performance.

During the first night of operations with USS KINKAID, the VMR sent 49 targets against the ship in an hour and a half, all of which the ship tracked. On the second day of the operation, another 37 targets were presented to the USS KINKAID, which "fired" on six of the threat missiles, scoring four kills.

Conclusion

The initial version of the sea-based VMR was successfully Tested and Evaluated using a progressive T&E discipline and is now operational. It was designed, developed, tested, and evaluated on schedule and within budget. Future versions of the VMR will include: 1) an electronic countermeasures capability, 2) additional platforms, 3) multi-axis synthetic threat presentations, 4) additional missile systems, and 5) maneuvering threats.